

Report for 2004ND49B: Analysis and Model Simulation of Stormwater Runoff -- A Study of Land Use and System Design on Discharge Flow Rates and Water Quality

Publications

- Conference Proceedings:
 - Somayajula. S., Gautam, B., Martin, J. and Lin, W. (2005). "Application of Water Quality Modeling in Red River Fecal Coliform TMDL Development." Presented at 'Research and Education in an International Watershed: Implications for Decision Making', Second International Water Conference, April 6-7, 2005, Winnipeg, Canada.
 - Martin, J., Somayajula, S., Gautam, B., Lin, W., Fredrick, J., and Ell, M. (2005). "Stormwater Sampling and Analysis for Red River Fecal Coliform and Turbidity TMDL Development." Presented at 'Research and Education in an International Watershed: Implications for Decision Making', Second International Water Conference, April 6-7, 2005, Winnipeg, Canada

Report Follows

ANALYSIS AND MODEL SIMULATION OF STORMWATER RUNOFF -- A STUDY OF LAND USE AND SYSTEM DESIGN ON DISCHARGE FLOW RATES AND WATER QUALITY

Fellow: Brajesh Gautam

Faculty Advisers: Wei Lin and G. Padmanabhan

DESCRIPTION OF THE CRITICAL WATER PROBLEM

The Red River of the North is an important resource for water supply and recreational purposes. However, the reach of Red River main stem covering Moorhead, MN and Fargo, ND areas has been identified as impaired for swimming designated use (primary contact recreation) under Section 303(d) of the Clean Water Act (CWA). The main causes contributing to impairment are excessive fecal coliform bacteria and high turbidity. High ammonia concentration in the river is another concern. An analysis of Red River quality data shows that urban runoff is a major source of fecal coliform and suspended solids. Fish kill in this reach of Red River occurred after a storm in August 2003. During the period of fish kill, low dissolved oxygen (DO) was observed in the river. Low flow rate in the river and high BOD concentration in the urban runoff were believed to be the reasons for the low DO and subsequent fish kill. The impact of urban runoff on the quality of a water body may vary significantly depending upon its existing water quality and the rates at which pollutants are introduced into the system. So we need to study flow of the runoff and major contaminant concentration. Loads of pollutants from runoff need to be calculated to accurately assess the effect of urban runoff and to propose control measures. The first step in the calculation of load is to estimate runoff. Runoff quantity is governed by the hydrological and physical characteristics of the drainage area. Simulation models are now days widely used in estimating stormwater flows in urban areas. More advanced models can simulate pollutants concentration in addition to flow and stages. So to find a broader picture of the affect of urban runoff on the Fargo Moorhead reach of Red River, sampling of the runoff and using this data to simulate a model is proposed.

The proposed research will be incorporated and synchronized with other related works going on with the view of analyzing the urban runoff of Fargo-Moorhead area. There is currently a study going on to estimate the Total Maximum Daily Load (TMDL) for the Fargo-Moorhead reach of the Red River. In this regard samples have been collected by River Keepers, the city of Moorhead and ND Department of Health. A number of samples from different location has been collected and analyzed for fecal coliform analysis and turbidity analysis. The analysis of 2002 data identified that fecal coliform is mainly being discharged from the urban area. The stormwater sampling and initial data show high BOD, fecal coliform and turbidity in storm runoff.

Following conclusions were drawn from that study.

- Fecal coliform impairment was present mainly in the urban section of the river.

- High fecal coliform counts were related with rain events and stormwater runoff from urban areas was identified as the main source of fecal coliform.
- Turbidity impairment was observed in both the urban and rural section of the river. Stormwater runoff might have caused increase of turbidity but the reach was impaired in both dry and wet seasons.

RESEARCH OBJECTIVES

Based on the observation from the summer 2002 sampling results, a study plan was developed. The purpose of the study was to get a better understanding of the broader aspect of urban runoff pollution in addition to aiding the source assessment and linkage analysis elements of the Red River TMDL development project. The approach adopted during the study was a combination of stormwater runoff sampling and computer modeling. The following are the objectives:

- Use water quality samples to determine the concentration of pollutant in storm runoff from different land use dominated areas within Fargo-Moorhead urban area
- Use flow measurement data to develop hydrograph for stormwater runoff
- Calibrate Stormwater Management Model (SWMM) for the Fargo-Moorhead urban runoff
- Calculate the Fecal Coliform and Total Suspended Solids (TSS) loads from Fargo- Moorhead urban areas
- Study the effects of land use and management practices on runoff flow and concentration of fecal coliform and TSS

RESULTS

Initial phase of the study consisted of review of literature pertaining to non-point source pollution, storm water runoff and urban runoff. During the summer of 2004, runoff flow and quality sampling was carried out in different landuse dominated sub drainage areas of cities of Fargo and Moorhead. The sampling results were used to generate flow hydrograph and fecal coliform and TSS pollutograph. The initial results showed a higher concentration of fecal coliform in commercial areas. With subsequent sampling, the effects of other major factors such as antecedent dry days, intensity and duration of the rainfall were also observed.

The sampling work provided the base for modeling of the runoff. The sampling results were used to calibrate SWMM model. Matching the total volume was given priority during the hydrograph calibration process. As total load was the primary focus of the analysis, loadograph calibration was suggested instead of pollutograph calibration. The calibrated model was then simulated for calculation of total volume and total load of fecal coliform and TSS from all the Fargo Moorhead drainage areas. In addition, the SWMM model has been used as a tool to analyze the impact of Sanitary Sewer Bypass on the Red River fecal coliform concentration and to calculate the critical conditions for high fecal coliform concentration in the Red River.

